APPENDIX: ANALOG TRANSMISSION PERFORMANCE OBJECTIVES:

The following long-haul reference circuit information is based on Jansen and Prime [9] unless otherwise noted. The 4000-mile ATT hypothetical reference circuit is composed of 150 equal-distance radio hops. The system consists of 51 main stations with IF switching and 100 IF repeater stations (50 cascaded IF switching sections with two IF repeaters in each section). Of the 51 main terminals, 17 are multiplex terminals. These are assumed to be interconnected by FM terminals (FM modulator and demodulator pair), wireline entrance links, and multiplex (at channel, group, or supergroup level). The multiline switching section is 1 x N [20].

Worst-case end-to-end circuit noise for the 4000-mile system during periods of nonfaded transmission is 41 dBrnC0. The noise may increase to 55 dBrnC0 during fading, after which the channel will be switched automatically to a protection channel. Single-tone interference of -68 dBm0 (41 dBrnC0) is the maximum for any voice circuit in the 4000-mile circuit during unfaded transmission. Under normal conditions, this corresponds to -87 dBm0 per hop (only one-half the hops accumulate the tone). Subjective tests have shown that, if the noise-to-tone power ratio in a message circuit is constant, the tone is less discernible when the noise power is increased. The result is that the requirement for those baseband tones that increase dB for dB with fading is -47 dBm0 when the circuit noise is 55 dBrnC0 (during a 40-dB fade).

Unfaded end-to-end noise of 41 dBrnC0 (11,220 pW0p) has been allocated as follows:

a. +31.2 dBrnC0 for 16 pairs of channel, group, and supergroup multiplex. If frogging reduces intermodulation buildup to 10 log n, this equates to a single-pair multiplex objective of 19.2 dBrnC0 (74.1 pW0p).
b. +28.0 dBrnC0 for 16 pairs of wireline entrance links. If intermodulation buildup is 10 log n, this equates to a single-pair objective of 16 dBrnC0 (35.5 pW0p).
c. +29.0 dBrnC0 for 16 pairs of FM terminals (modulator and demodulator pair). If intermodulation buildup is 10 log n, this equates to a single-pair objective of 17 dBrnC0 (44.7 pW0p).
d. +39.9 dBrnC0 (8710 pW0p) for 150 hops of radio. The radio noise is subdivided as follows:
    1. +28 dBrnC0 for (same route) cochannel interference. This equates to +6.2 dBrnC0 (3.7 pW0p) per hop.
    2. +26 dBrnC0 for cochannel (converging route) interference. This equates to +4.2 dBrnC0 (2.3 pW0p) per hop.
    3. +29 dBrnC0 for intersystem interference. If two exposures per hop are assumed, this equates to +4.2 dBrnC0 (2.3 pW0p) per exposure per hop.
e. +28 dBrnC0 for RF echo distortion. This equates to +6.2 dBrnC0 (3.7 pW0p) per hop.
f. +22 dBrnC0 for IF (interconnect) echo distortion. With 100 IF interconnects, this equates to +2.0 dBrnC0 (1.4 pW0p) per IF hop.
g. +25 dBrnC0 for tertiary interference. For 50 IF switch sections, this equates to +8.0 dBrnC0 (5.6 pW0p) per 3-hop IF section.
h. +38.4 dBrnC0 to 150 microwave transmitter and receiver pairs. This noise is further subdivided as follows:
    1. +36.9 dBrnC0 for thermal noise. This equates to +15.1 dBrnC0 (28.8 pW0p) per hop (10 log n addition).
    2. +33.1 dBrnC0 for intermodulation noise. This equates to +2.6 dBrnC0 (1.6 pW0p) per hop. This is based on measured intrasection intermodulation addition of 19 log n yielding an end-to-end intermodulation noise buildup of 14 log n. It is interesting to note that intermodulation noise of cascaded identical devices has

been shown experimentally to add on an approximately 20 log n basis regardless of whether the devices are connected at baseband [2] or at RF [9].

3. The total unfaded end-to-end noise of 41 dBrnC0 is equivalent to an objective of 1.74 pW0p/km. The total unfaded radio noise of +39.9 dBrnC0 is equivalent to an objective of 1.35 pW0p/km.

The above is based on the following general system characteristics:

1 pWC0 = 0 dBrnC0 = -88 dBm0 (unweighted).

1 pW0p = 0 dBrnp0 = -87.5 dBm0 (unweighted).

System is 1800 channels with CCIR emphasis.

Typical hop is 26.7 miles (42.9 km) long.

Nominal loss between transmitter output (power into transmit filter) and receiver input (power into receiver filter) is 63 dB.

Expected end to end RF frequency translation is less than 312 kHz.

IF selectivity at adjacent channel center frequency is 10 dB.

Minimum crosspolarization discrimination (XPD) is 25 dB.

Back-to-back antenna coupling loss is 66 dB.

Side-to-side antenna coupling is 80 dB for copolarization and 83-dB for cross-polarization.

ATT has a short-haul reference circuit [1] in addition to the long-haul reference circuit. The short-haul reference circuit is 10 hops of baseband interconnected radio extending over 250 miles. It has the same end-to-end noise objectives and outage allocations as does the long-haul system. The implied assumption is that a subscriber-to-subscriber voice circuit is connected over either the short-haul or long-haul circuits, but not both.

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Figure 1 Tertiary Interference Paths

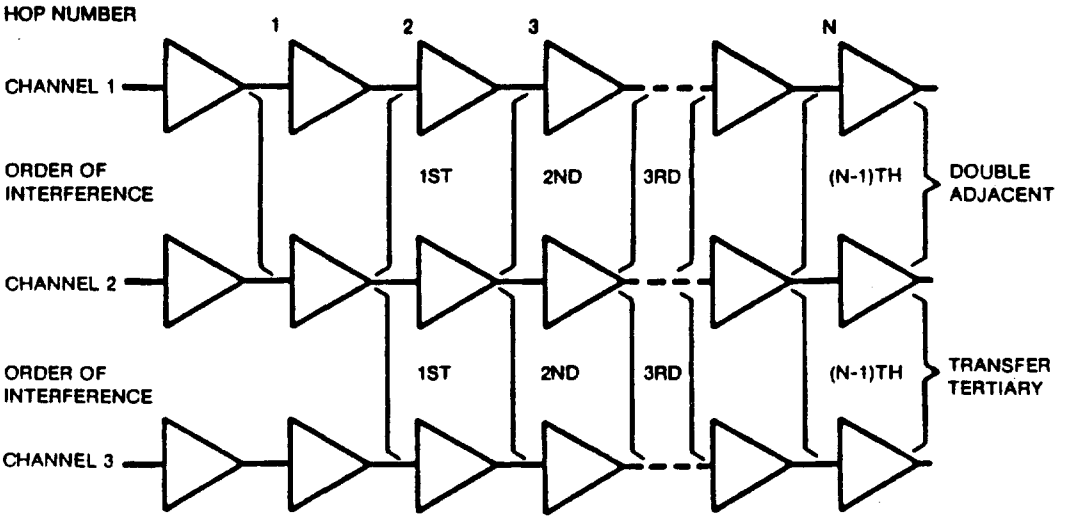


Figure 2 Composite IF/RF Receiver Response

2400 FDM–FM Channels

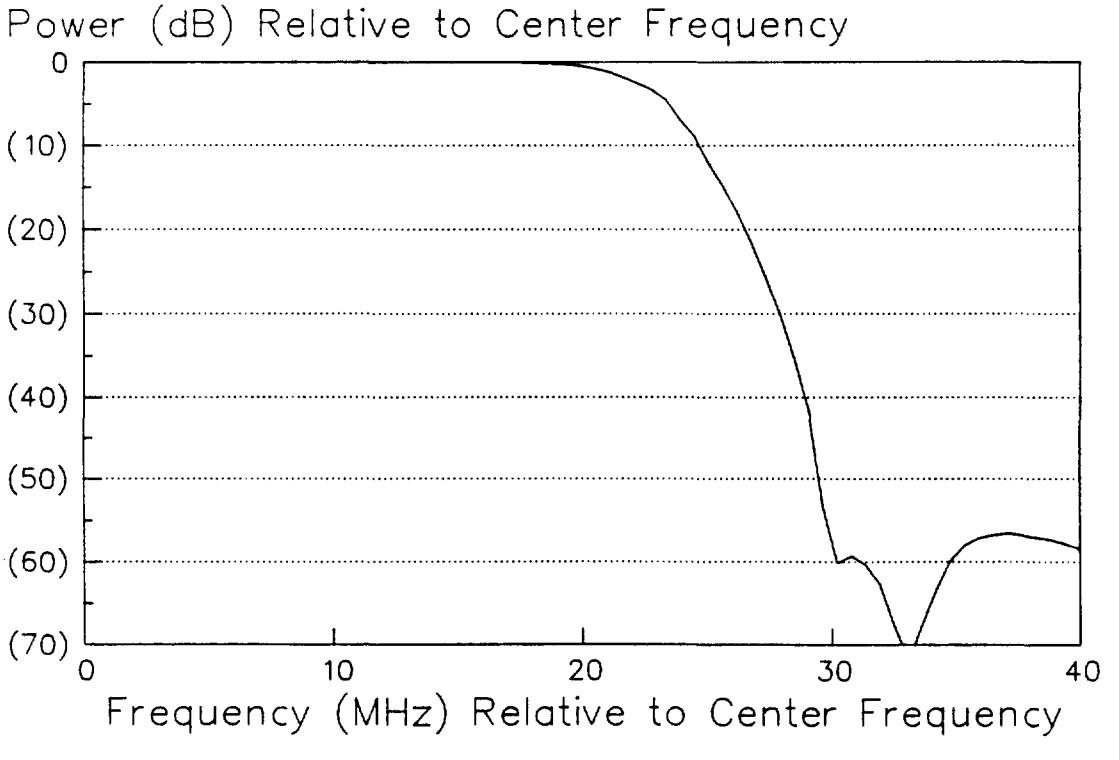


Figure 3 Typical Angle Modulation Spectrums

Power in 4 kHz Bandwidth
Relative to Unmodulated Carrier

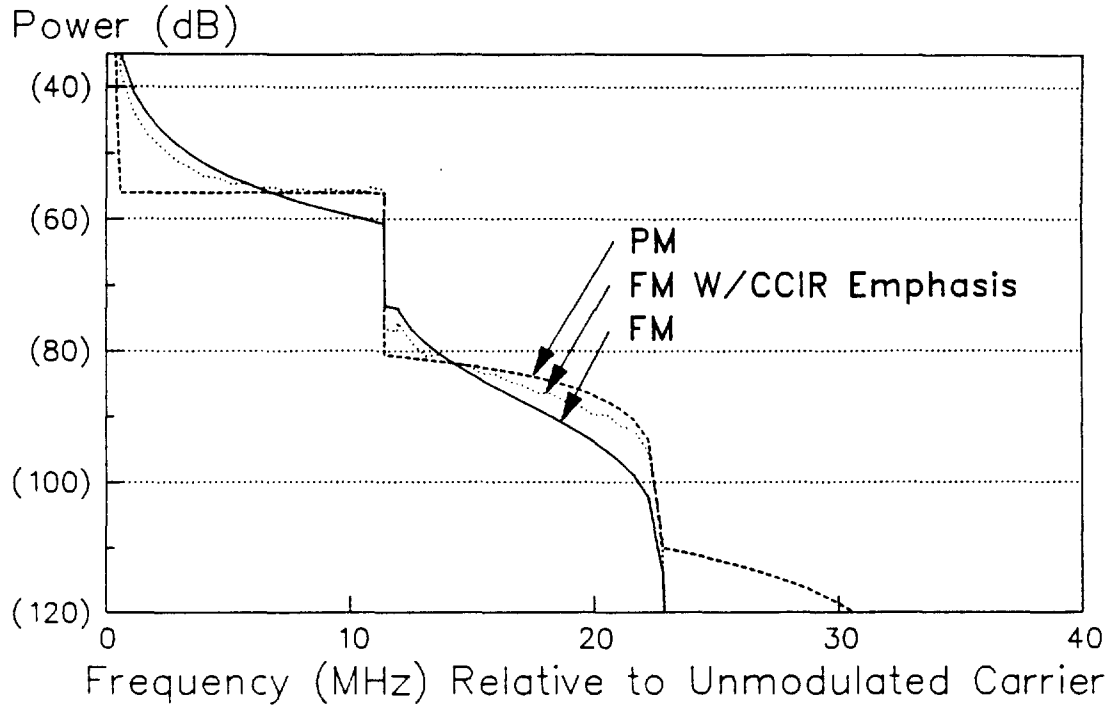


Figure 4 Typical Digital Modulation Spectrums

Power in 4 kHz Bandwidth
Relative to Unmodulated Carrier

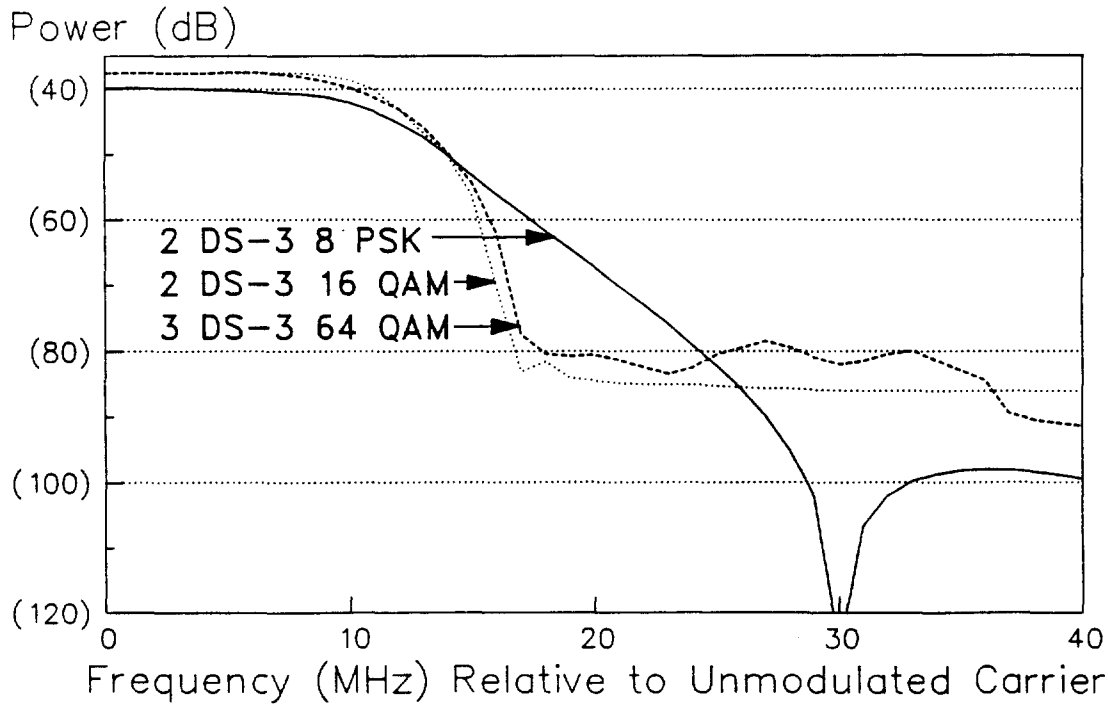


Figure 5 Angle Modulation Interference Curves

Both C and I the Same Modulation Type

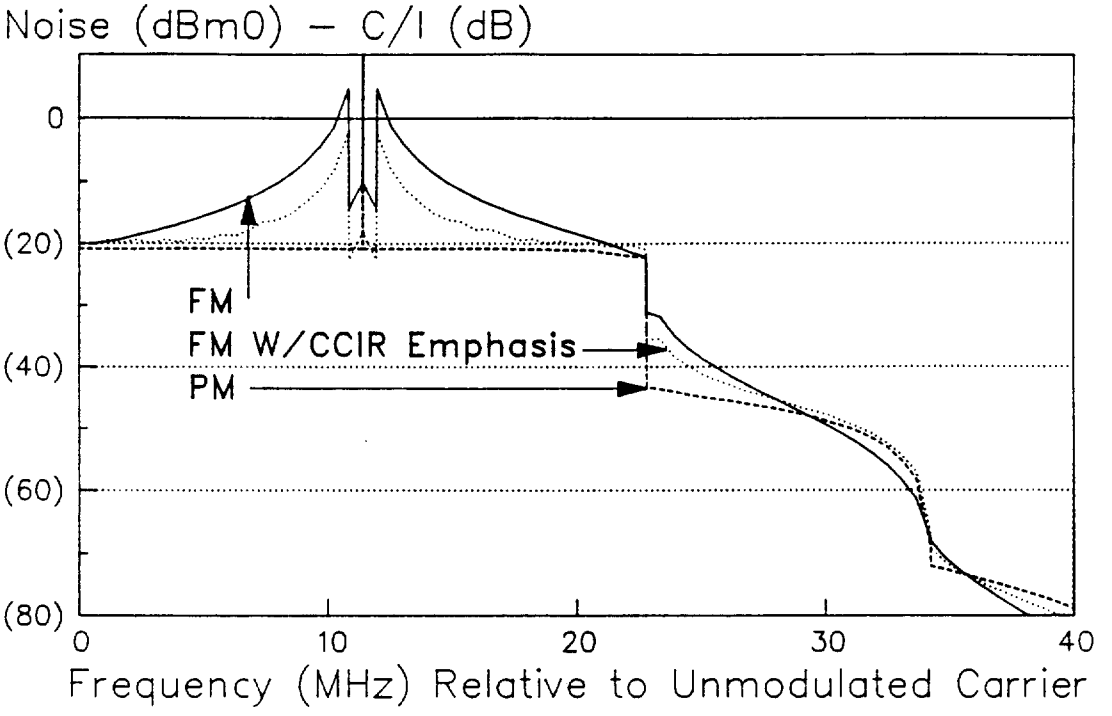


Figure 6 Angle Modulation Interference Curves

Angle Modulation is 2400 Channel FDM

Interference is 2 DS–3 8 PSK Digital

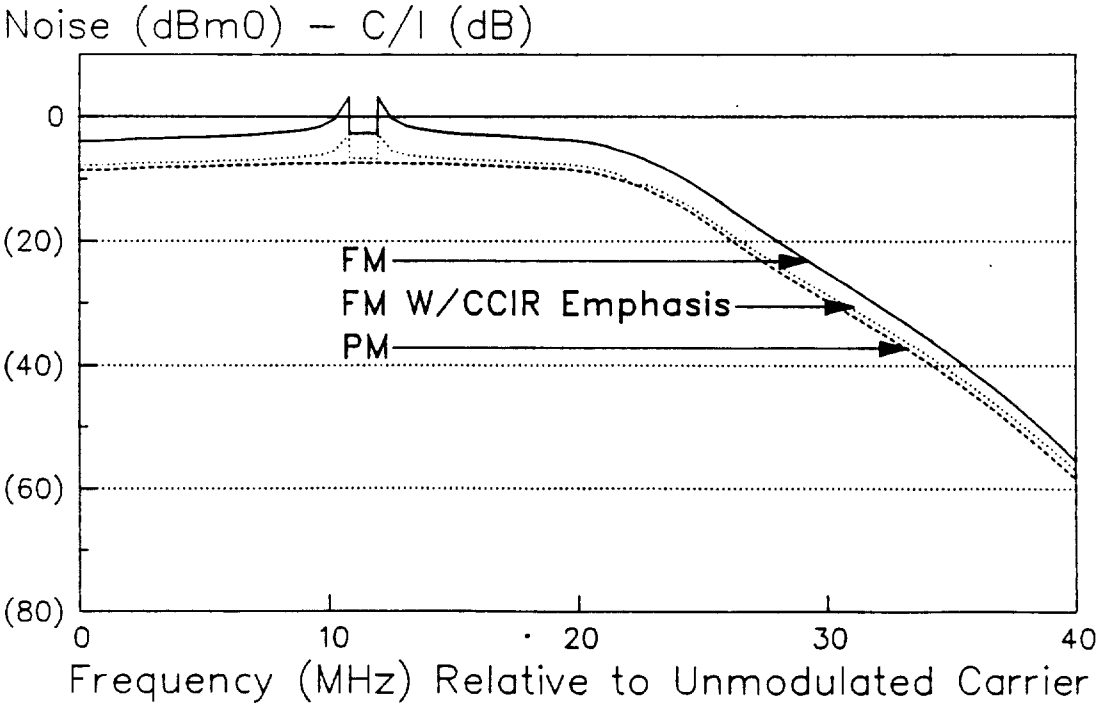


Figure 7 Angle Modulation Interference Curves

Angle Modulation is 2400 Channel FDM

Interference is 2 DS-3 16 QAM

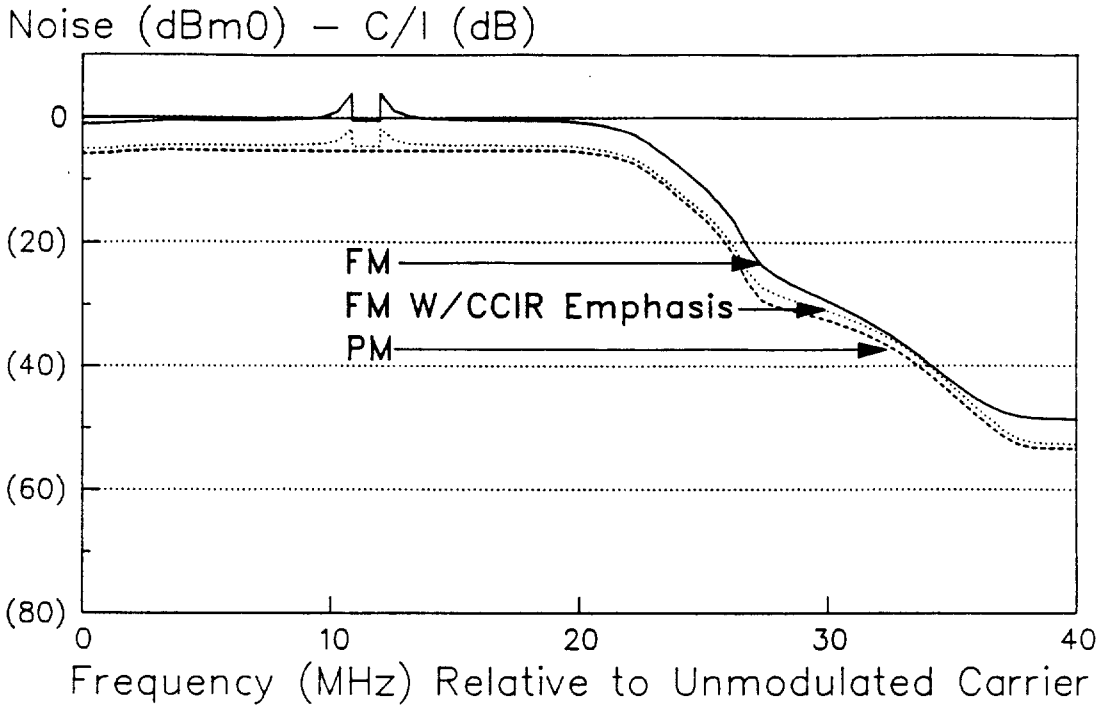


Figure 8 Angle Modulation Interference Curves

Angle Modulation is 2400 Channel FDM

Interference is 3 DS-3 64 QAM

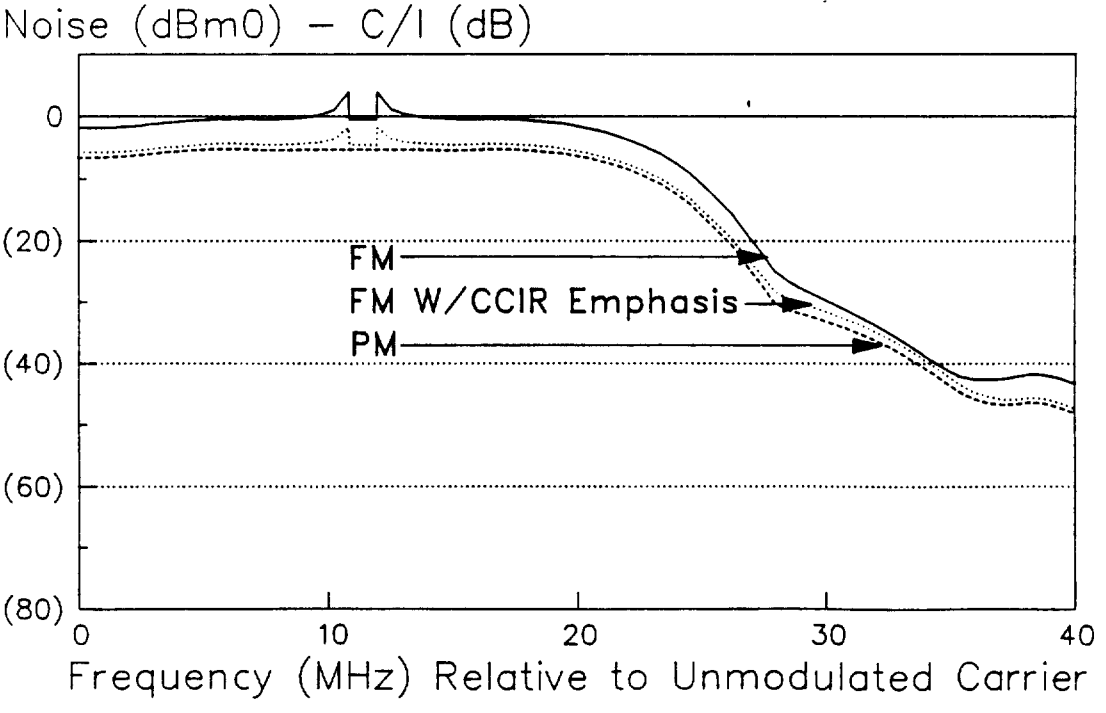


Figure 9 Actual Interference Noise

FM Receiver with CCIR Emphasis

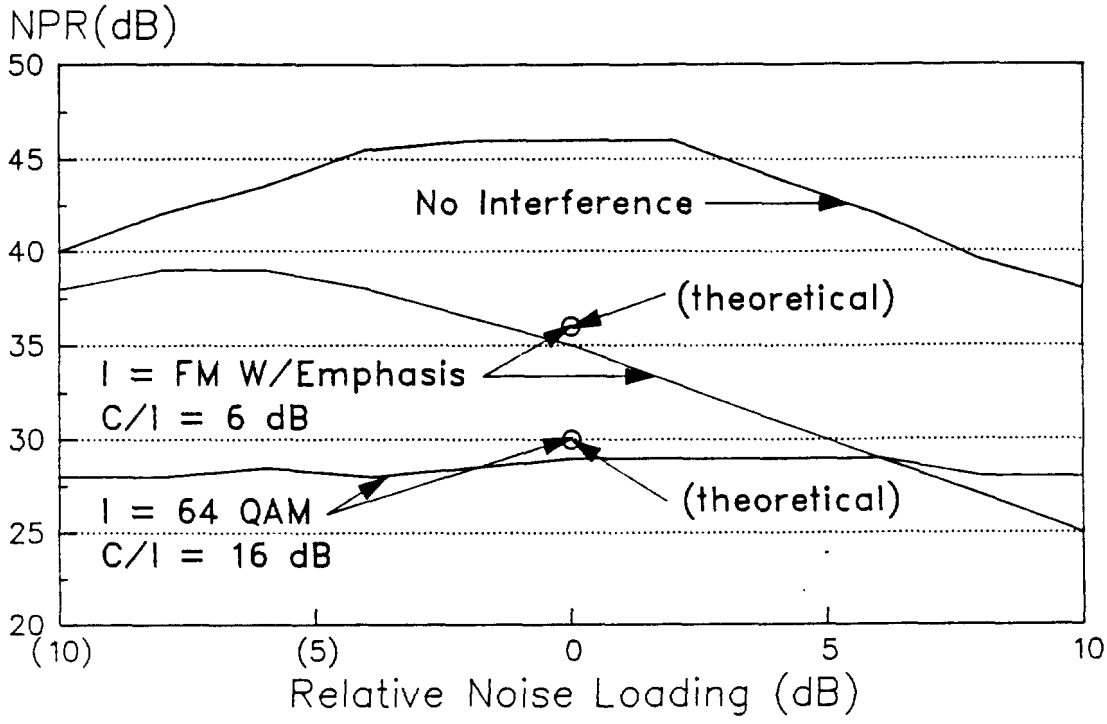
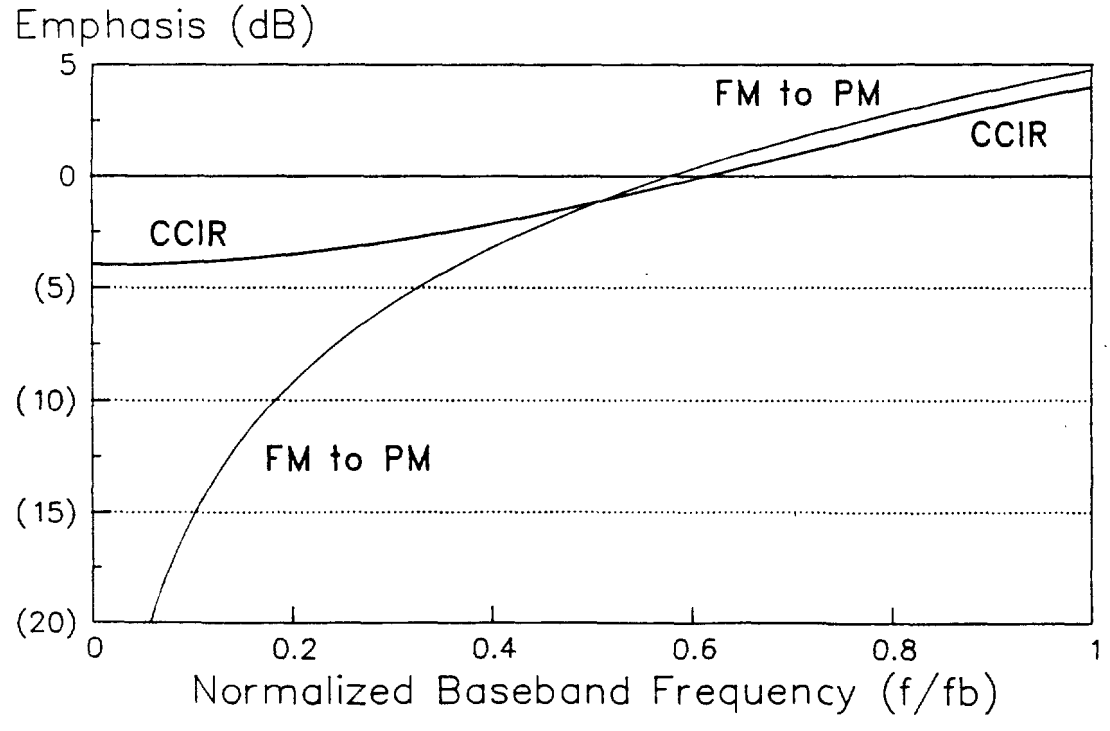


Figure 10 Emphasis Curves



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